



Process Approach to Detecting Early Cognitive Impairment

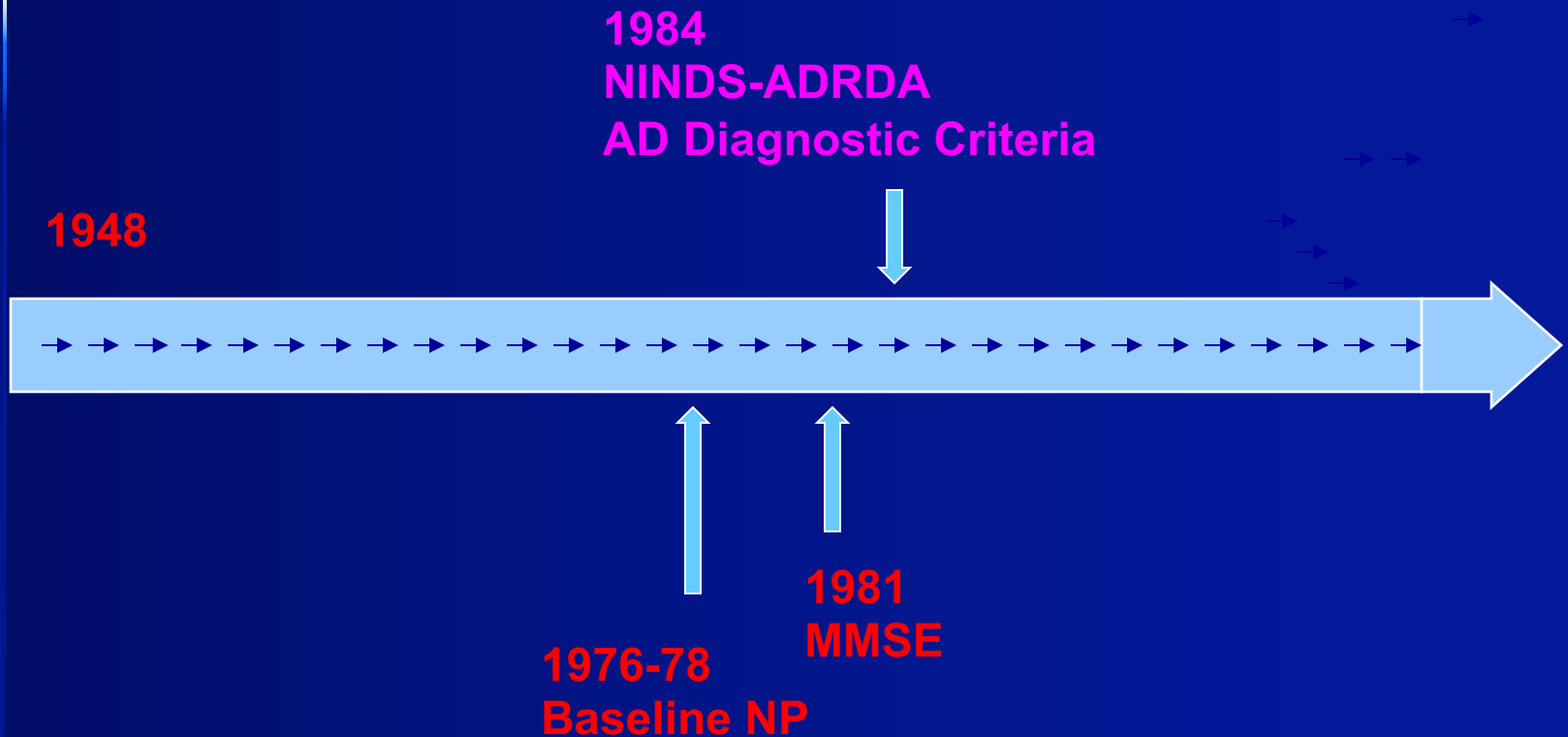
Rhoda Au, Ph.D.,MBA
Friday Harbor
9/14/15

Objectives

- Understanding of full scope of FHS cognitive data
- How neuropsychological tests are a richer resource than they are typically used
- Preview of things to come

Framingham Heart Study

Dementia Study – Prevalence: Gen 1 Original cohort



Cogniitve Measures – 1976-78

Gen 1 - Exam 14/15

WMS Logical Memory – IR & DR

WMS Visual Reproductions - IR

WMS Paired Associates - IR

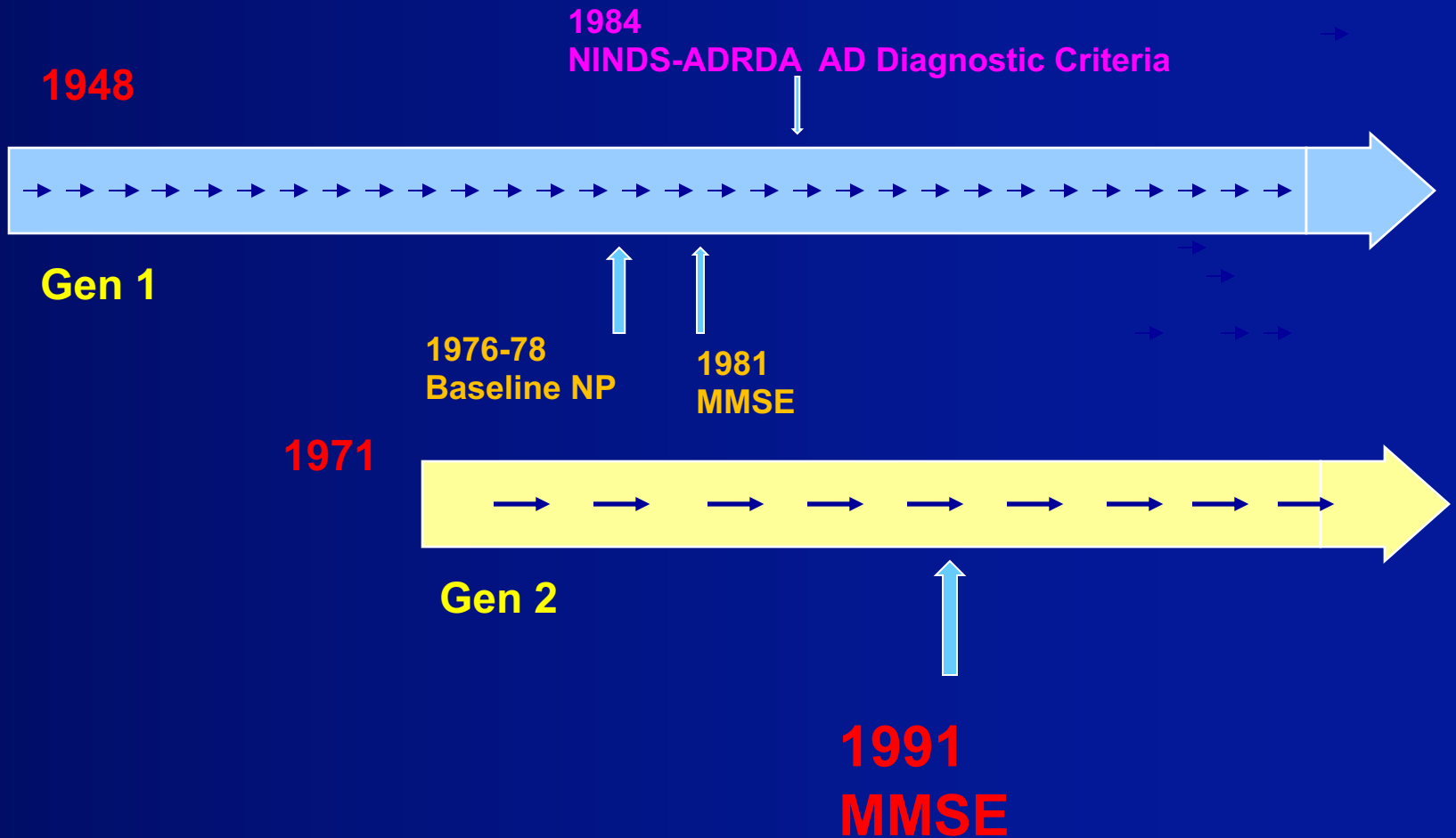
WMS Digit Span

WAIS Similarities

Controlled Word Association Test - FAS

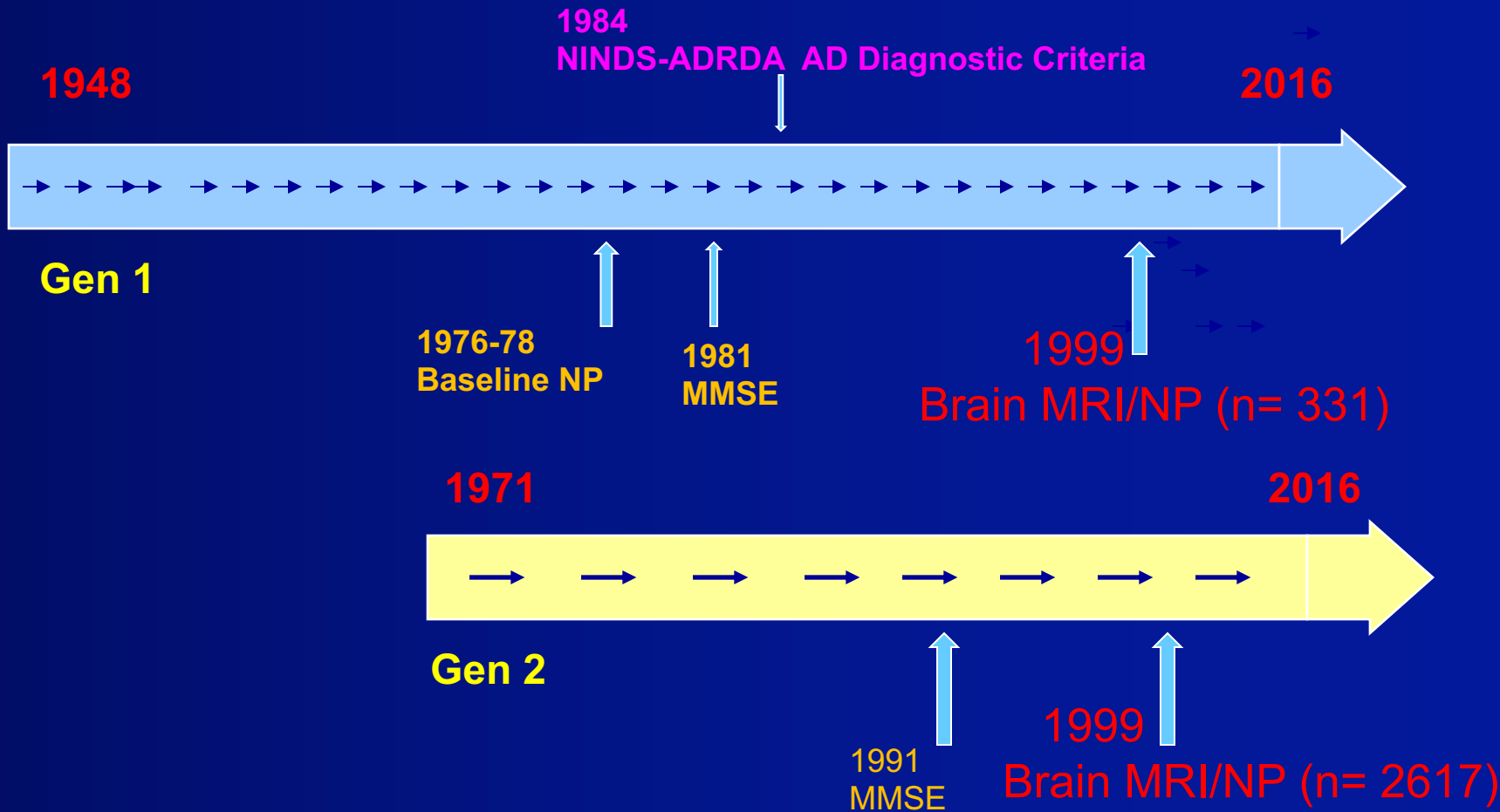
Framingham Heart Study

Dementia Incidence – Add Gen 2 Offspring cohort



Framingham Heart Study

Incident Dementia + Pre-Clinical



Cognitive Tests - 1999-2005

Gen 1 – Exams 25-27

Gen 2 – Exam 7

WMS Logical Memory – IR & DR

WMS Visual Reproductions – IR & DR

WMS Paired Associates – IR & DR

WAIS Similarities

~~Digit Span~~

~~Controlled Word Association Test – FAS~~

Trails A & B

Boston Naming Test – 30 Item

Hooper Visual Organization Test

Finger Tapping

WRAT III Reading Subtest

Mild Cognitive Impairment

1999:

Preclinical AD

2004:

Amnestic

Memory Only – Verbal and/or Visual
Memory + Other Cognitive Domains

Non-Amnestic

Single Domain
Multiple Domains

Cognitive Impairment Detection Challenge: FHS Current Two-Method Approach

- The Traditional Approach
- Boston Process Approach
 - Preserve traditional measures
 - Expand test beyond single score
 - Focus on path to final response
 - Value of incorrect responses

Cognitive Tests – 2005-2011

Gen 1 – Exam 28

Gen 2 – Exam 8

WMS Logical Memory – IR & DR & Recogn

WMS Visual Reproductions – IR & DR & Recogn

WMS Paired Associates – IR & DR & Recogn

WAIS Similarities

Digit Span

Controlled Word Association Test – FAS

Category Fluency - Animals

Trails A & B

Boston Naming Test – 30 Item

Hooper Visual Organization Test

Finger Tapping

WRAT III Reading Subtest

Clock Drawing Test

WISC-III Math Fluency

Digit Symbol Substitution Test

Quantitative vs. Qualitative: LM –IR

Traditional scores

Total verbatim

Total paraphrase

Total – V+P

Qualitative Scores

Confabulations related

Intrusions related

Confabulations unrelated

Intrusions unrelated

Total Number of Qualitative Measures = 10

Quantitative vs. Qualitative: LM –DR

Qualitative measures from IR PLUS:

Confabulations

Related & Unrelated from IR
Related & Unrelated - New

Intrusions

Related & Unrelated from IR
Related & Unrelated - New

Total Number of Qualitative Measures = 14

Digit Span – Qualitative Errors

Differentiate between sequencing and non-sequencing errors

Sequencing Error example:

For 1 – 5 – 2 – 8 – 6, participant responds 6 – 8 – 2 – 1 – 5

Non-sequencing Error examples:

✦ For 1 – 5 – 2 – 8 – 6, participant responds 6 – 8 – 2 – 5

✦ For 1 – 5 – 2 – 8 – 6, participant responds 6 – 3 – 2 – 1 – 5

Digit Span – Limit Testing

Testing the limits

STANDARD DISCONTINUE

TESTING THE LIMITS



ACTUAL DISCONTINUE

| Digit Span (Backward) (WAIS) | | Check here if test NOT completed (usual reason for not completing test on last card) |
|------------------------------|--|---|
| Score | 0 = incorrect, non-sequencing error 1 = incorrect, sequencing error only 2 = correct 3 = not administered | Circle the longest correct span length. Underline the longest span scored "2" or "3" AFTER the official discontinue. |
| Example 1: 7-4-2-1-1 | Example 2: 2-4-4 | |
| 1-4 | 5-8 | Span = 2 |
| 6-2-9 | 4-1-5 | Span = 3 |
| 3-2-7-9 | 4-9-6-8 | Span = 4 |
| 1-5-2-8-6 | 6-1-8-4-3 | Span = 5 |
| 5-3-9-4-1-8 | 7-2-4-8-5-6 | Span = 6 |
| 8-1-2-9-3-6-5 | 4-7-3-9-1-2-8 | Span = 7 |
| 9-4-3-7-6-2-5-8 | 7-2-8-1-9-6-5-3 | Span = 8 |

Digit Span

Calculating Qualitative Scores

Calculate total score accounting for continuum of error types

- 1) Score each trial [0, 1, or 2]**
- 2) Assign qualitative value for each digit span [scale 0 to 5]**
- 3) Sum qualitative values for qualitative total score**

Digit Span – Scoring Trials

TRIAL SCORING:

- 2 = correct response
- 1 = incorrect response (sequencing error)
- 0 = incorrect response (non-sequencing error)
- 8 = not administered

Digit Span (Backward) (WAIS)

Check here if the NPT completed
word form for scoring on a test page.

Key:
0 = incorrect
1 = incorrect, sequencing error only
2 = correct
8 = not administered

Span Length: 1 to 9
1 to 9: Do the largest span you can. 10: Do not do this if you did not do 9.

| | |
|-----------------|-----------------|
| 1-4 | 5-8 |
| 6-2-9 | 4-1-5 |
| 3-2-7-9 | 4-9-6-8 |
| 1-5-2-8-6 | 6-1-8-4-3 |
| 5-3-9-4-1-8 | 7-2-4-8-5-6 |
| 8-1-2-9-3-6-5 | 4-7-3-9-1-2-8 |
| 9-4-3-7-6-2-5-8 | 7-2-8-1-9-6-5-3 |

Digit Span – Scoring Spans

SPAN SCORING:

| TRIAL #1 | TRIAL #2 | QUALITATIVE SCORE |
|----------|----------|-------------------|
| 2 | 8 | 5 |
| 1 | 2 | 4 |
| 0 | 2 | 3 |
| 1 | 1 | 2 |
| 1 | 0 | 1 |
| 0 | 1 | 1 |
| 0 | 0 | 0 |

Digit Span (Backward) (WAIS)

Check here if test NOT completed

Forward score for set completed but not last page

Score: 0 = incorrect
1 = incorrect, repeating error only
2 = correct
3 = not administered

Span length: Circle the longest correct span length
Indicate the longest span scored "1" or "2" ALL in the field of scoring

Qualitative Score

Example: 5-4-3-2-1-2-3 Example: 3-4-5

1-4 Span=2

6-2-9 Span=3

3-2-7-9 Span=4

1-5-2-8-6 Span=5

5-3-9-4-1-8 Span=6

8-1-2-9-3-6-5 Span=7

9-4-3-7-6-2-5-8 Span=8

4-1-5 Span=3

1-9-6-8 Span=4

6-1-8-4-3 Span=5

7-2-4-8-5-6 Span=6

4-7-3-9-1-2-8 Span=7

7-2-8-1-9-6-5-3 Span=8

PARTICIPANT #1 - - 78 YR OLD WOMAN WITH SOME COLLEGE

PARTICIPANT #2 - - 78 YR OLD WOMAN WITH SOME COLLEGE

| Digit Span (Backward) (WAIS) | | Check here if test NOT completed <input type="checkbox"/> | |
|--|---------------------------------------|--|---------------------------------------|
| 0 = incorrect, non-sequencing error 1 = incorrect, sequencing error only 2 = correct 3 = not administered | | (Circle the longest correct span length.) (Underline the longest span scored "2" or "3" AFTER the official discussion.) | |
| Example 1: 1-1-8-2-7-1 Example 2: 3-4-8-1-2-3 | | | |
| 1-4 | # of correct <input type="checkbox"/> | 5-8 | # of correct <input type="checkbox"/> |
| 6-2-9 | # of correct <input type="checkbox"/> | 4-1-5 | # of correct <input type="checkbox"/> |
| 3-2-7-9 | # of correct <input type="checkbox"/> | 4-9-6-8 | # of correct <input type="checkbox"/> |
| 1-5-2-8-6 | # of correct <input type="checkbox"/> | 6-1-8-4-3 | # of correct <input type="checkbox"/> |
| 5-3-9-4-1-8 | # of correct <input type="checkbox"/> | 7-2-4-8-5-6 | # of correct <input type="checkbox"/> |
| 8-1-2-9-3-6-5 | # of correct <input type="checkbox"/> | 4-7-3-9-1-2-8 | # of correct <input type="checkbox"/> |
| 9-4-3-7-6-2-5-8 | # of correct <input type="checkbox"/> | 7-2-8-1-9-6-5-3 | # of correct <input type="checkbox"/> |
| QUANTITATIVE SCORE (longest digit span) = <u>4</u> | | QUALITATIVE TOTAL SCORE = <u>35</u> | |

| Digit Span (Backward) (WAIS) | | Check here if test NOT completed <input type="checkbox"/> | |
|--|---------------------------------------|--|---------------------------------------|
| 0 = incorrect, non-sequencing error 1 = incorrect, sequencing error only 2 = correct 3 = not administered | | (Circle the longest correct span length.) (Underline the longest span scored "2" or "3" AFTER the official discussion.) | |
| Example 1: 1-1-8-2-7-1 Example 2: 3-4-8-1-2-3 | | | |
| 1-4 | # of correct <input type="checkbox"/> | 5-8 | # of correct <input type="checkbox"/> |
| 6-2-9 | # of correct <input type="checkbox"/> | 4-1-5 | # of correct <input type="checkbox"/> |
| 3-2-7-9 | # of correct <input type="checkbox"/> | 4-9-6-8 | # of correct <input type="checkbox"/> |
| 1-5-2-8-6 | # of correct <input type="checkbox"/> | 6-1-8-4-3 | # of correct <input type="checkbox"/> |
| 5-3-9-4-1-8 | # of correct <input type="checkbox"/> | 7-2-4-8-5-6 | # of correct <input type="checkbox"/> |
| 8-1-2-9-3-6-5 | # of correct <input type="checkbox"/> | 4-7-3-9-1-2-8 | # of correct <input type="checkbox"/> |
| 9-4-3-7-6-2-5-8 | # of correct <input type="checkbox"/> | 7-2-8-1-9-6-5-3 | # of correct <input type="checkbox"/> |
| QUANTITATIVE SCORE (longest digit span) = <u>4</u> | | QUALITATIVE TOTAL SCORE = <u>20</u> | |

Qualitative errors – Trails B

Perceptual Errors

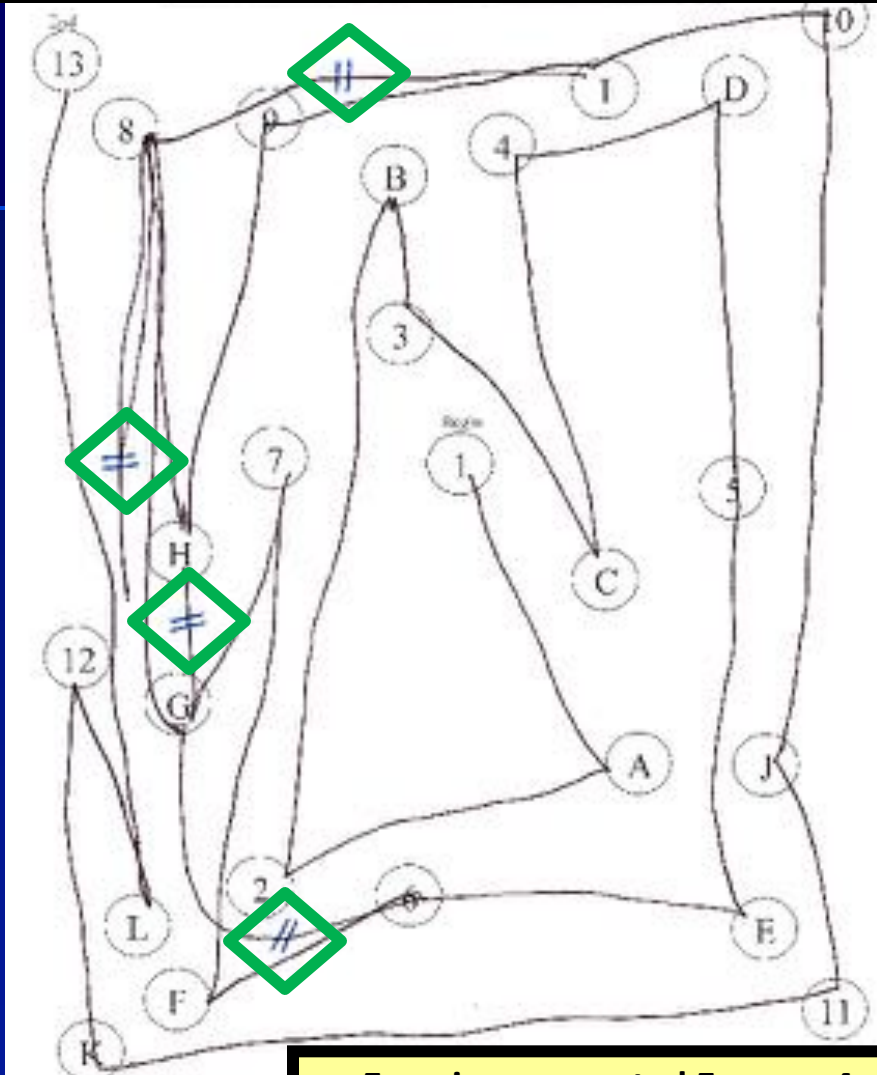
Other Errors

Self-corrected &
Examiner-corrected

Pen lifts

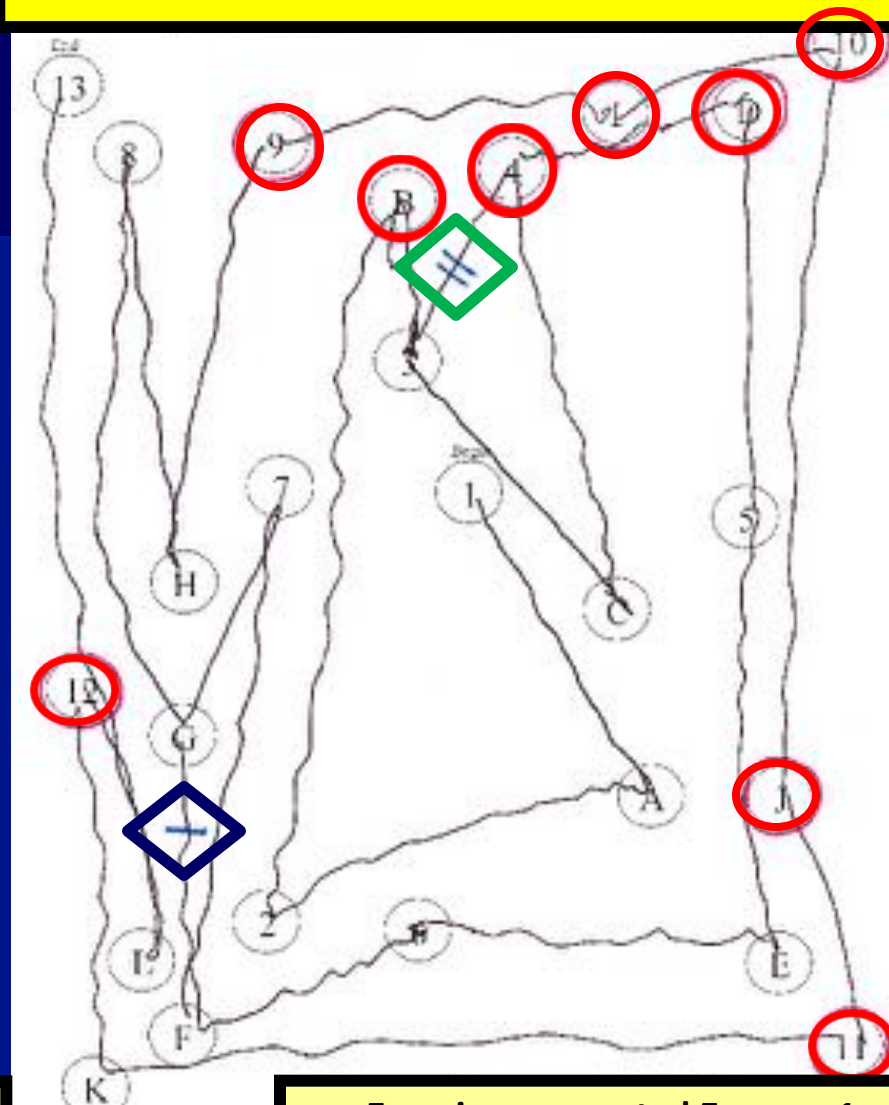
Starts before told to begin

PARTICIPANT #1 -- 77 YR OLD WOMAN HIGH SCHOOL GRADUATE



Examiner-corrected Errors: 4
Self-corrected Errors: 0

PARTICIPANT #2 -- 80 YR OLD WOMAN HIGH SCHOOL GRADUATE



Examiner-corrected Errors: 1
Self-corrected Errors: 1
Pen lifts: 9

TIME TO COMPLETE

TIME TO COMPLETE

Qualitative errors

Verbal fluency

FAS

Wrong first letter

Broken rules

Perseverations

ANIMALS

Broken rules

Perseverations

Verbal Fluency

PARTICIPANT #1 - 78 YR OLD MAN Total FAS Score = 39

| Verbal Fluency (FAS) | | | | | Check here if test NOT completed (provide reason for not completing test on last page) | | |
|--|--|--|---|---------------------------------|---|--------------|-------------------|
| Write all words produced by participant in the appropriate space. Place the number of correct words in each box. | | | | | Number of | | |
| | 0-15 (sec) | 16-30 (sec) | 31-45 (sec) | 46-60 (sec) | Wrong First Letter | Broken Words | Pre- or -suffixes |
| F | foil fun fact family facility 6 | folk fetter fettuccine 2 | 0 | 0 | 0 | 0 | 0 |
| A | apple aspiration amble acting asphalt 6 | angel ample agile accelerate 3 | applaud appear appoint attend 4 | attack attune appeal 3 | 0 | 0 | 0 |
| S | saying simple soft specific 4 | satisfy stain super stay school 5 | supervise stray suppose 3 | static stoic step 3 | 0 | 0 | 0 |

Verbal Fluency

PARTICIPANT #2 - 81 YR OLD MAN Total FAS Score = 39

| Verbal Fluency (FAS) | | | | | Check here if test NOT completed <small>(insert reason for not completing test on last page)</small> | | |
|--|--|---|--|---|---|--------------|-------------|
| Write all words produced by participant in the appropriate space. Place the number of correct words in each box. | | | | | Number of: | | |
| | 0-15 (sec) | 16-30 (sec) | 31-45 (sec) | 46-60 (sec) | Wrong First Letter | Broken Words | Repetitions |
| F | find follow friend fool fake fabulous frank 7 | follow fake find 0 | fabulous food 1 | fries frankfurter 2 | 0 | 0 | 4 |
| A | apple ample accurate astounding artifact apricot 6 | aggregate acrimony activity arousal 4 | above abet abysmal abate 4 | above 0 | 0 | 0 | 1 |
| S | save simple savage sample cigarette save sagacity shrimp 4 | save sagacity shrimp 2 | sure shore shambles shock shit shoreline 6 | sample sugar shome ship 3 | 1 | 0 | 2 |

Category Fluency - Animals

■ 64-year old woman

- Quantitative- 15 responses
- Qualitative- 0 errors

| | | | | | | | |
|---------|----------|-----------------------------|-------------------|--------------------|---|---|---|
| ANIMALS | cat | pony hippopotamus fly | mosquito snake | bird cow pig | X | 0 | 0 |
| | dog | | | | X | | |
| | elephant | | | | X | | |
| | tiger | | | | X | | |
| | puma | | | | X | | |
| horse | | 7 | 3 | 2 | 3 | | |

■ 62-year old man

- Quantitative- 15 responses
- Qualitative- **3 errors**

| | | | | | | | |
|---------|-----------|--|----------------------------|--------------------|---|---|---|
| ANIMALS | cat | antelope deer alligator crocodile koala bear | bear beaver cockatoo | snake alligator | X | 0 | 3 |
| | dog | | | | X | | |
| | elephant | | | | X | | |
| | osprey | | | | X | | |
| | porcupine | | | | X | | |
| skunk | | 6 | 5 | 3 | 1 | | |

Process Across Tests:

Executive Function - Perseverations Across Tests

Logical memory - # perseverations: IR & DR

Visual Reproductions – perseverations (Y/N
per design: IR & DR

Paired Associates – perseveration/pair: IR

Similarities – perseveration/item

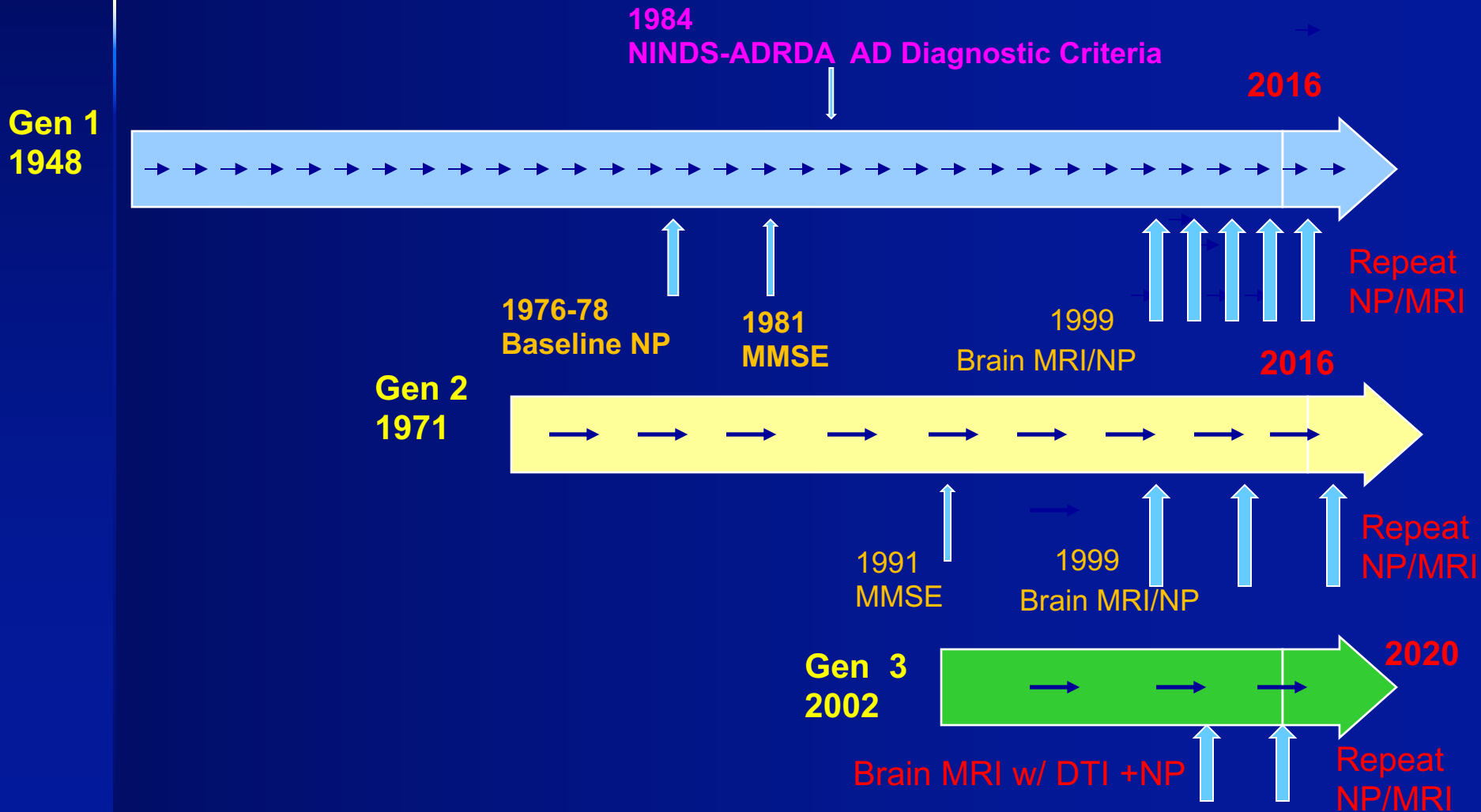
FAS - # of perseverations/trial

Animals - # of perseverations

BNT – perseveration/item

Framingham Heart Study

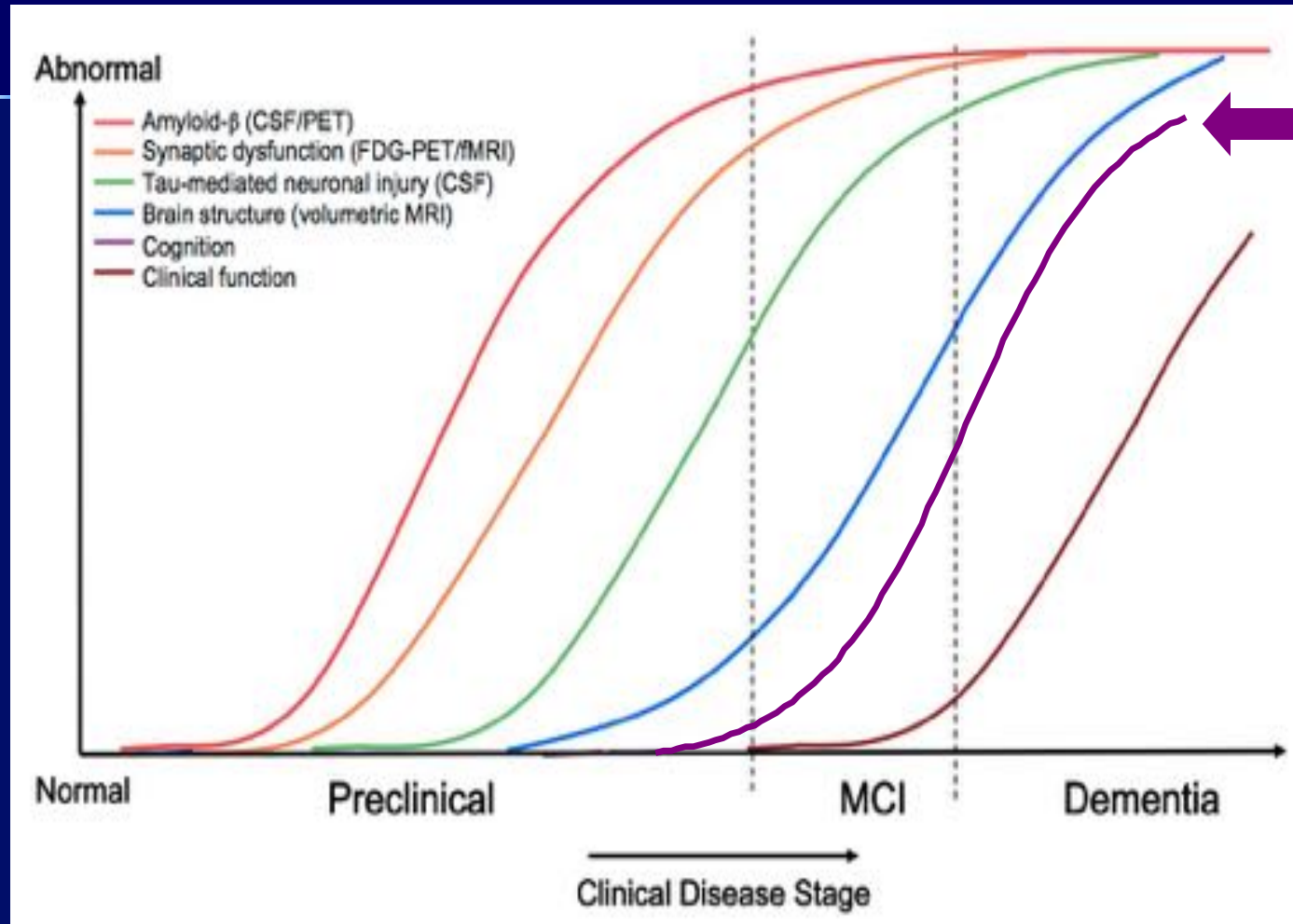
Incident Dementia + Pre-Clinical + Asymptomatic



What is Pre-clinical?

- 65+ years old
 - Measures differentiate cognitively intact vs. clinically demented
- 45-65 years old
 - Measures differentiate cognitively intact vs. pre-clinical
- <45 years old
 - Measures differentiate cognitively intact vs. cognitively intact

Cognitive Impairment Detection Challenge: When Can It Be Detected?



BPA on Steroids

Digital Clock Drawing Test - 2011

The screenshot displays the ClockSketch V3.8 software interface. The central window shows a hand-drawn clock face with numbers 1 through 12 and two hands. The interface includes a left sidebar with patient information fields, a right sidebar with classification lists for 'COPY' and 'COMMAND' classes, and a bottom control panel with buttons for 'Play Sketch', 'Reset Sketch', and 'Classify'.

Classifier: COPY

- XOut Persev Dip: XDPer
- XOut Hand: XH
- XOut Digit: XD
- Two: 2
- Twelve: 12
- Three: 3
- Ten: 10
- Six: 6
- Seven: 7
- Partial Of: PCF
- One: 1
- Nine: 9
- Minute Hand: MH
- Hour Hand: HH
- Four: 4
- Five: 5
- Eleven: 11
- Eight: 8
- Clockface: CF
- Center Dot: CD
- Un-Stroke: T
- Tick-Mark: TMO
- Tick: TT
- Spokes: SPOKES
- Over Twelve: OT
- Not Clock Data: NCD
- None: NOSE

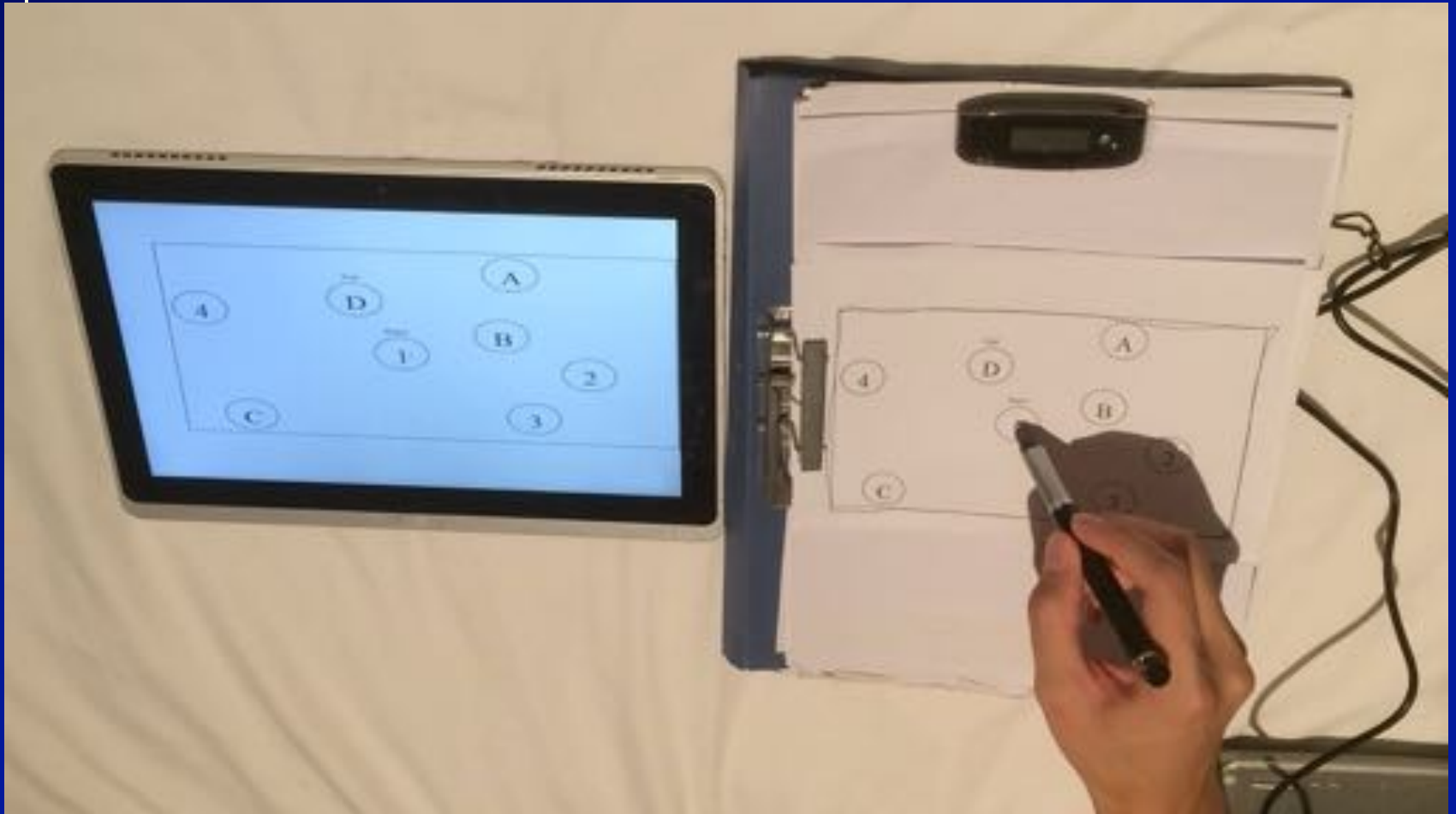
Classifier: COMMAND

- XOut Persev Dip: XDPer
- XOut Hand: XH
- XOut Digit: XD
- Two: 2
- Twelve: 12
- Three: 3
- Ten: 10
- Six: 6
- Seven: 7
- Partial Of: PCF
- One: 1
- Nine: 9
- Minute Hand: MH
- Hour Hand: HH
- Four: 4
- Five: 5
- Eleven: 11
- Eight: 8
- Clockface: CF
- Center Dot: CD
- Un-Stroke: T
- Tick-Mark: TMO
- Tick: TT
- Spokes: SPOKES
- Over Twelve: OT
- Not Clock Data: NCD
- None: NOSE

Test Date: Wed 27 Jan 2010 9:12AM EST
9:53:46 AM



e-NP Platform



FHS Cognitive Data Today

- Initial BPA data collection in Gen 3 (2009-2013)
- Repeat BPA data collection in Gen 2 (2010-2016)
- Repeat BPA in Gen 3 (2015 -2020)
- Digital Ink technology (2011-2020)
- e-NP Platform (2016 – 2020)